

WHAT IS CLAIMED IS:

- 1           1.    A method of generating return-to-zero (RZ)  
2   optical data in a digital lightwave communications  
3   system, comprising the steps:  
4                providing radio frequency (RF) electrical data  
5   to a first stage modulator for modulating a light input  
6   so as to generate an intermediary optical data output  
7   having a non-return-to-zero (NRZ) format;  
8                controlling a phase difference between said  
9   intermediary optical data output and a clock signal  
10   associated therewith using a feedback control loop  
11   operable responsive at least in part to a phase dither  
12   reference signal;  
13                adjusting said clock signal based on a phase  
14   control signal provided by said feedback control loop to  
15   generate a phase-adjusted clock signal; and  
16                providing said phase-adjusted clock signal to  
17   a second stage modulator operable to blank out a select  
18   portion of data intervals of said intermediary optical  
19   data output for creating optical data having an RZ  
20   format.

1           2.    The method of generating RZ optical data as set  
2    forth in claim 1, wherein said RF electrical data is  
3    operable in a Gigabits per second (Gbps) range.

1           3.    The method of generating RZ optical data as set  
2    forth in claim 1, wherein said step of controlling a  
3    phase difference comprises the steps:

4                    providing an output generated by a synchronous  
5    (SYNC) detector operable to detect signal transitions in  
6    said optical data due to a phase difference between said  
7    intermediary optical data output and said clock signal to  
8    an amplifier stage, said SYNC detector operating  
9    responsive at least in part to an RF amplitude dither  
10   reference signal in an RF data amplitude feedback control  
11   loop associated with said first stage modulator;

12                   providing an output generated by said amplifier  
13   stage to a phase SYNC detector operating in response to  
14   said phase dither reference signal to generate a phase  
15   error signal; and

16                   providing said phase error signal to a phase  
17   error amplifier having its reference input grounded, said  
18   phase error amplifier operating to generate an output  
19   signal that is groomed into said phase control signal.

1           4.    The method of generating RZ optical data as set  
2    forth in claim 3, wherein said output signal is groomed  
3    in a voltage limitation step.

1           5.    The method of generating RZ optical data as set  
2    forth in claim 4, wherein said voltage limitation step is  
3    followed by adding a phase dither signal.

1           6.    The method of generating RZ optical data as set  
2    forth in claim 3, wherein said first stage modulator  
3    comprises a Mach-Zehnder modulator.

1           7.    The method of generating RZ optical data as set  
2    forth in claim 3, wherein said second stage modulator  
3    comprises a Mach-Zehnder modulator.

1           8.    The method of generating RZ optical data as set  
2    forth in claim 3, wherein said select portion of said  
3    data intervals comprises approximately a half data  
4    interval.

1           9.    The method of generating RZ optical data as set  
2    forth in claim 3, wherein said first and second stage  
3    modulators are associated with an optical transmitter  
4    disposed in a long-haul digital lightwave communications  
5    system.

1           10. The method of generating RZ optical data as set  
2           forth in claim 3, further comprising the steps:  
3                 effectuating a bias point feedback control loop  
4           associated with said first stage modulator;  
5                 effectuating an RF clock amplitude feedback  
6           control loop associated with said second stage modulator;  
7           and  
8                 effectuating a bias point feedback control loop  
9           associated with said second stage modulator.

1           11. The method of generating RZ optical data as set  
2           forth in claim 10, wherein said RF data amplitude  
3           feedback control loop associated with said first stage  
4           modulator is a 1<sup>st</sup> order negative feedback control loop.

1           12. The method of generating RZ optical data as set  
2           forth in claim 10, wherein said RF clock amplitude  
3           feedback control loop associated with said second stage  
4           modulator is a 1<sup>st</sup> order negative feedback control loop.

1           13. The method of generating RZ optical data as set  
2           forth in claim 10, wherein said bias point feedback  
3           control loop associated with said first stage modulator  
4           is a 1<sup>st</sup> order negative feedback control loop.

1           14. The method of generating RZ optical data as set  
2           forth in claim 10, wherein said bias point feedback  
3           control loop associated with said second stage modulator  
4           is a 1<sup>st</sup> order negative feedback control loop.

1           15. The method of generating RZ optical data as set  
2           forth in claim 3, wherein said light input is provided by  
3           a continuous wave (CW) laser source.

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1           16. A system for generating return-to-zero (RZ)  
2 optical data in a digital lightwave communications  
3 system, comprising:

4           a first stage modulator operable to modulate a  
5 light input into an intermediary optical data output  
6 having a non-return-to-zero (NRZ) format based on a radio  
7 frequency (RF) electrical data provided thereto;

8           a feedback controller operable to control a  
9 phase difference between said intermediary optical data  
10 output and a clock signal associated therewith, said  
11 feedback controller for generating a phase control  
12 signal;

13           a phase adjuster operable to adjust said clock  
14 signal into a phase-adjusted clock signal based on said  
15 phase control signal; and

16           a second stage modulator operable to blank out  
17 a select portion of data intervals of said intermediary  
18 optical data output for creating optical data having an  
19 RZ format, said second stage modulator operating  
20 responsive at least in part to said phase-adjusted clock  
21 signal.

1           17. The system for generating RZ optical data as  
2 set forth in claim 16, wherein said RF electrical data is  
3 operable in a Gigabits per second (Gbps) range.

1           18. The system for generating RZ optical data as  
2 set forth in claim 16, wherein said feedback controller  
3 includes:

4           an amplifier stage operable to receive an  
5 output generated by a synchronous (SYNC) detector  
6 operating to detect signal transitions in said optical  
7 data due to a phase difference between said intermediary  
8 optical data output and said clock signal, said SYNC  
9 detector operating responsive at least in part to an RF  
10 amplitude dither reference signal in an RF data amplitude  
11 feedback controller associated with said first stage  
12 modulator;

13           a phase SYNC detector coupled to said amplifier  
14 stage for receiving an output therefrom, phase SYNC  
15 detector operating in response to a phase dither  
16 reference signal to generate a phase error signal; and

17           a phase error amplifier operable responsive to  
18 said phase error signal, said phase error amplifier for  
19 generating an output signal that is groomed into said  
20 phase control signal.

1           19. The system for generating RZ optical data as  
2 set forth in claim 18, wherein said feedback controller  
3 further includes a voltage limiter for limiting said  
4 output signal to a predetermined range.

1           20. The system for generating RZ optical data as  
2 set forth in claim 19, wherein said feedback controller  
3 further includes means for adding a phase dither signal  
4 to said voltage limiter's output.

1           21. The system for generating RZ optical data as  
2 set forth in claim 18, wherein said first stage modulator  
3 comprises a Mach-Zehnder modulator.

1           22. The system for generating RZ optical data as  
2 set forth in claim 18, wherein said second stage  
3 modulator comprises a Mach-Zehnder modulator.

1           23. The system for generating RZ optical data as  
2 set forth in claim 18, wherein said select portion of  
3 said data intervals comprises approximately a half data  
4 interval.

1           24. The system for generating RZ optical data as  
2 set forth in claim 18, wherein said first and second  
3 stage modulators are associated with an optical  
4 transmitter disposed in a long-haul digital lightwave  
5 communications system.



1           25. The system for generating RZ optical data as  
2 set forth in claim 18, further comprising:  
3           a bias point feedback controller associated  
4 with said first stage modulator for providing a bias  
5 control signal thereto;  
6           an RF clock amplitude feedback controller  
7 associated with said second stage modulator for providing  
8 an RF clock amplitude control signal thereto; and  
9           a bias point feedback controller associated  
10 with said second stage modulator for providing a bias  
11 point control signal thereto to optimally bias said  
12 optical data.

1           26. The system for generating RZ optical data as  
2 set forth in claim 25, wherein said RF data amplitude  
3 feedback controller associated with said first stage  
4 modulator is a 1<sup>st</sup> order negative feedback control  
5 circuit.

1           27. The system for generating RZ optical data as  
2 set forth in claim 25, wherein said RF clock amplitude  
3 feedback controller associated with said second stage  
4 modulator is a 1<sup>st</sup> order negative feedback control  
5 circuit.

1           28. The system for generating RZ optical data as  
2 set forth in claim 25, wherein said bias point feedback  
3 controller associated with said first stage modulator is  
4 a 1<sup>st</sup> order negative feedback control circuit.

1           29. The system for generating RZ optical data as  
2 set forth in claim 25, wherein said bias point feedback  
3 controller associated with said second stage modulator is  
4 a 1<sup>st</sup> order negative feedback control circuit.

1           30. The system for generating RZ optical data as  
2 set forth in claim 18, wherein said light input is  
3 provided by a continuous wave (CW) laser source.